2022 International Conference on Knowledge Engineering and Communication Systems (ICKES)

Deployment of Autonomous Vehicles in Agricultural and using Voronoi Partitioning

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2022 International Conference on Knowledge Engineering and Communication Systems (ICKECS) | 978-1-6654-5637-1/22/$31.00 ©2022 IEEE | DOI: 10.1109/ICKECS56523.2022.10060773

***Abstract*—There will be nine billion people on the planet by the year 2050, according to most estimates, thus agricultural output must rise steadily. In order to deal with the increasing population, agricultural chores must be mechanized and automated. The autonomous and safe navigation of ground robots has been one of the most difficult challenges in their development over the past decade. With the emergence of the "smart city" movement, automated vehicles have become a hot issue. Authorities and administrators are unprepared to deal with the anticipated disruption of autonomous vehicles, which might potentially replace traditional transportation. We don't yet know how new capabilities will disrupt existing systems and what policy solutions will be necessary to counteract this disruption. Autonomous vehicles have a variety of advantages and disadvantages that must be considered. One such challenge is its path planning. Autonomous vehicle path planning in dynamic situations is a critical yet difficult issue because of the limitations imposed by vehicle dynamics and the presence of other vehicles. Vehicle trajectories include a variety of operations, including lane holding, lane shift, ramp merging, and crossing the street at an intersection. In order to operate autonomously, a mobile platform must perform a variety of tasks such as localization and mapping, as well as motion control and path planning. We'll look at a bunch of different ways path planning may be put to use in farming in this post. This paper, proposed a Voronoi based partitioning algorithm which is used to find the optimal path for the intelligent vehicles. The Minimum Spanning Tree is computed and the problem is posed as a Travelling Salesperson Problem. The solution for the problem is obtained by solving using various greedy approaches. The results are compared while using various algorithms for the results obtained through the proposed partitioning algorithm.**

Keywords—Agriculture, Minimum Spanning Tree, Autonomous Vehicles, Travelling Salesperson Problem.

I. INTRODUCTION

Sustainable and smart vehicle technologies are integrated with cooperative intelligent transportation systems (ITS) via cloud-servers and big-data-based vehicle networks, as initially envisaged under the smart cities agenda, to describe the smart urban mobility idea [1]. In other terms, "smart urban mobility" is defined as a combination of urban transportation services and smart technology. Autonomous vehicle or automated car, self-driving car, or driverless car—is undoubtedly one of the most sophisticated applications that leverages various ITS capabilities as part of the smart urban transportation system [2]. Automated driving refers to the use of electronic and/or mechanical equipment to do part or all of the work of driving. Automatic driving has its earliest roots in the early twentieth century. Autonomous speed, brake, lane, and other basic cruise control functions were the focus of the technology at the time [3]. However, major technical developments in the industry have only occurred in the last decade or two due to the incubation circumstances of the Digital and 4th Industrial Revolutions, which have resulted to various prototype AVs being trailed on the roads [4].

It's no secret that proponents of autonomous vehicles say that using GPS and big data to better manage crops would help solve the world's water and food problems [5]. Unfortunately, autonomous vehicle technology has had little influence on farming methods until lately. Autonomous vehicle applications in agriculture and precision farming have gained a lot of traction recently. Autonomous vehicles are altering agricultural operations for farmers and agricultural advisors alike, allowing them to picture, rebuild, and analyze individual leaves on a corn plant from a height of 120 meters and obtain data on soil water-holding capacity and variable-rate water applications [6]. Shown in Fig 1. how drones help the farmers in spraying the pesticides over their farm land. They are also used for other monitoring purposes.

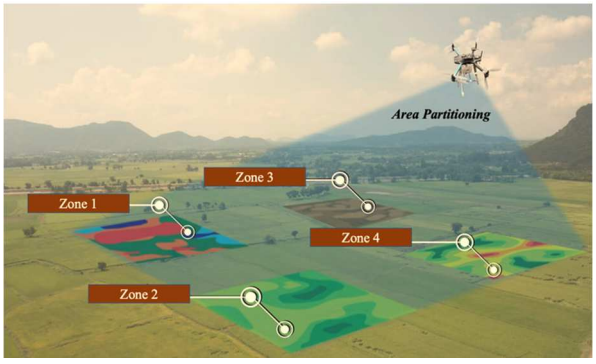

Fig. 1. Use of Autonomous Vehicle in Agriculture

Using autonomous vehicles primarily in precision agriculture necessitates technology that is both precise and easy to deploy, use, and afford. The most difficult part of

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every operation involving a UAV is directing it to a certain area and accomplishing the task assigned to it with the utmost accuracy and efficiency. There is a considerable probability that a UAV would wander from its intended destination because of faults in the GPS signals received. Due to User Equivalent Range Error (UERE) in GPS coordinates, the UAV may fly to a different field than the one intended. To overcome this challenge, in this paper we have introduced a new way of partitioning the geographic area under survey named Voronoi partitioning. With the help of the proposed algorithm, will be able to have an optimal path. The problem is posed as TSP by constructing the Minimum Spanning Tree and various algorithms are used to solve the same. The upcoming sections discuss on the various existing methods, the proposed methodology and the experimental results obtained.

II. RELATED WORKS

As the usage of unmanned aerial vehicles (UAVs) grows as discussed in [7], so does the need for aircraft that can fly on their own. This study explains how a cascaded PID controller with simultaneous localization and mapping may be used to build an autonomous UAV (SLAM). A quadcopter-style unmanned aerial vehicle (UAV) is made possible by a simple design and readily accessible components. It also includes a human detection neural network that may be utilized for a variety of purposes, such as aerial photography, search and rescue, and defense. The goal of this study was to see whether a UAV could land autonomously on another UAV is researched in [8]. To identify the base UAV, the agent UAV was equipped with a custom-trained Single Shot MultiBox Detector (SSD) network (base UAV). With the help of a robot operating system, a proportional-integral-derivative controller was used to regulate the landing (ROS). The findings indicated that the SSD network was able to locate and identify the Base UAV with a 99.9% success rate.

For UAV search vehicle routing [9], a method based on thermal in glider operations is offered here for consideration. The thermal method generates routes that show promise for fixed-wing, short endurance, and autonomous vehicle routing applications by using straight-line segments and very simple guiding logic. When signal readings and distance travelled are used as performance measurements. Autonomous vehicles have become an essential element of the mining industry's digital transition was proved and listed in [10]. Autonomous vehicles may now operate securely underground thanks to advances in lidar technology and SLAM algorithms. There are many hazardous and inaccessible regions in underground mines that prohibit conventional inspections, mapping, and monitoring from taking place. When it comes to safe autonomous vehicle flights in an underground mine, there are a lot of special considerations that need to be made.

Many industries are using autonomous vehicles, also known as autonomous vehicles. autonomous vehicles that can go to other planets have grown in popularity over the past decade. Movement on Mars has been confined to a narrow area due to the many methods employed to investigate the planet. A better solution was sought as a consequence of the employment of numerous autonomous vehicles in the exploratory process. Author was made an article regarding this area in [11]. A technique for stabilizing [12] films acquired by vision sensors mounted directly to a autonomous vehicle's frame has been developed in this work. Many applications may benefit from this method, vegetation maps, as well as an image registration process. Geometric distortions in video frames may be removed using the suggested method, which relies on affine and projective transformations to estimate and correct for them.

Traditional agricultural methods in [13], have been transformed into a new age of precision agriculture thanks to the Internet of Things (IoT) and autonomous vehicles. IoT and autonomous vehicle technologies in agriculture have been studied extensively in this article. Intelligent sensors, networks, and protocols, as well as smart agricultural IoT applications and solutions, are all covered in our overview of IoT technology. As a result, [14], agriculture has always relied on cutting-edge technology to maximize output, affordability, convenience, and environmental conservation. A recent example is the use of autonomous vehicles in agriculture. There are several advantages to using numerous autonomous vehicles in conjunction with each other. The selection of the proper routing protocol is one of the most difficult design challenges faced by multi-autonomous vehicle systems. Climate change and production efficiency must be addressed urgently as the world's population continues to grow. To solve and improve agriculture's challenges, autonomous vehicles offer a tremendous deal of promise since they can collect real-time data. Agriculture will increasingly employ autonomous vehicles, despite the fact that they have a number of constraints (battery, weight, weather conditions, etc.), due to their useful data and efficient uses in [15]. Military and disaster relief activities may both benefit from the self-configuring, fast deployable nature of the FANET. Since FANETs are dense networks, most mobility models assume that they will not produce accurate results in the actual world. There may be times when autonomous vehicles are unable to communicate with each other owing to low battery, malfunction, financial limits, or the nature of the application. For the first time, a three-dimensional simulator is used to accomplish the suggested work [16] on sparse networks.

In 6G networks in [17], an autonomous vehicle-enabled aerial network is essential for seamless coverage and high-speed connection. An autonomous vehicle-assisted and energy-constrained intelligent edge network studies the topic of joint task and energy offloading. Our suggested strategy outperforms the competition in terms of numerical simulation results. To fix the issue, we suggest a MASAC (multi-agent soft actor–critic) strategy. It is a revolutionary approach to using autonomous vehicles in [18]. A scalable collision avoidance flight plan may be implemented using this method to protect the swarm's unpredictable mobility. More than a thousand simulations have shown that the CSC technique is better than the ACO algorithm or deterministic group flocking rules. A potential technology is the ability to efficiently navigate a fleet of thousands of high-altitude balloons to offer a communication and information system for the whole Earth [19]. Based on the wind-assisted balloon's energy collection-consumption model and energy management technique, the energy limits may be derived. A multi-balloon system dynamic coverage method has been devised. To demonstrate the algorithm's efficacy, three different setups with 1500 balloons each are simulated at two different launch locations.

Corrosion attacks on onshore pipes are common [20]. The aggressiveness of the environment will cause new faults to arise between inspections. Aiming to detect deterioration increments and the locations of new faults by comparing two inspections, this study tackles the matching issue. The method

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was tested on a genuine pipeline with a length of 45 kilometers and on corrosion faults created in a lab. IoT's Quality of Service (QoS) metrics are fully dependent on the cooperation of devices throughout the routing process. Selfish conduct may lead to network collapse due to a variety of variables including energy depletion, adversary conquest, and resource limits [21]. An Internet of Things watchdog-based identification approach is described in this study in an effort to identify self-obsessed devices. Detection, false-positive, throughput, end-to-end latency, and energy consumption efficiency of the suggested technique have been verified. Processes based on data must make room for AI-driven frameworks [22]. The development of technology is focused on reducing the amount of data that must be transmitted and the amount of network traffic that must be handled [23].

III. METHODS

The key focus of the problem is to traverse a given agricultural land without any collision and also the path chosen is to be optimum. This means that the route chosen by the autonomous vehicle is to be minimum. The overall workflow of the proposed methodology is as shown in Fig. 2.

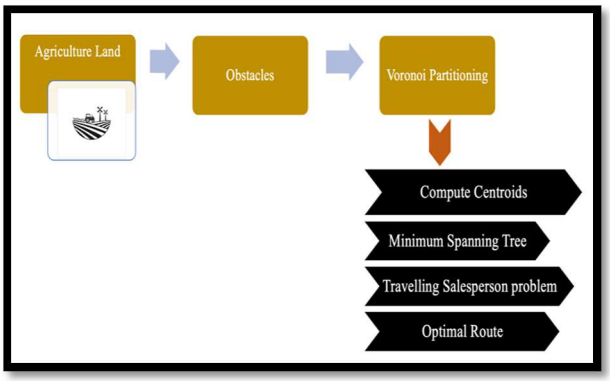

Fig. 2. Overall Scheme Flow

Initially the autonomous vehicles are deployed over a geographic area which needs to be surveyed. The study area that we have taken in our proposed work is as shown in Fig. 3 and the area is enlarged for better vision as shown in Fig. 4.

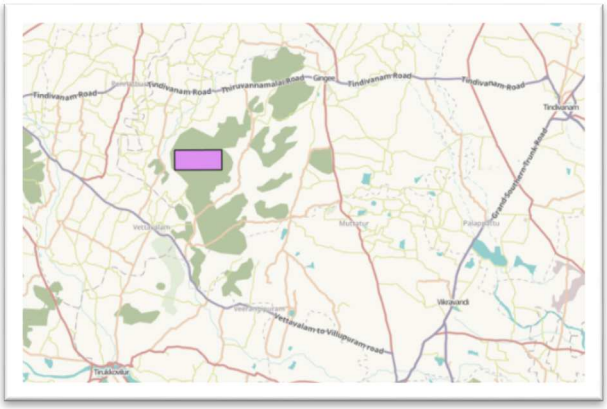

Fig. 3. Study Area

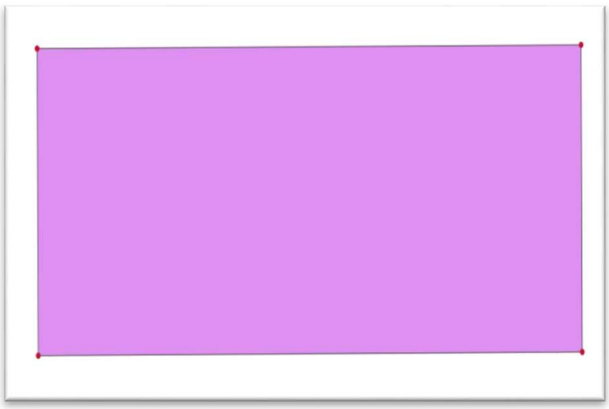

Fig. 4. Study area - Enlarged

Once the area is obtained now the vehicles needs to traverse the entire area for any specific application like surveillance or spraying of pesticides. But the traversing is not that easy as it may have obstacles like huge trees or even small building. In this study we have considered only static obstacles. The obstacles are located as shown in Fig. 5. Once the obstacles are obtained we perform the proposed methodology. The use of Voronoi partitioning on the geographic areas is done. The partitioning is based on the coordinates of the obstacles in such a way that while traversing the vehicle doesn't have a collision with the partition. In a Voronoi diagram, an area of a plane is divided up into areas that are near to a certain number of different things.

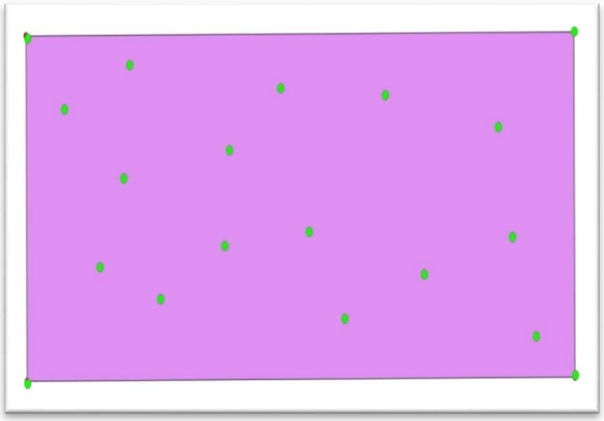

Fig. 5. Obstacles

In Fig. 6, we can see how the voronoi partitioning has been done in the presence of obstacles. Once the partitions are done, we compute the centroids of each partition and is depicted in Fig. 7. These centroids are used as the coverage points through which the vehicle needs to travel. The points are posed as Travelling Salesperson problem and are solved by making use of various greedy approaches.

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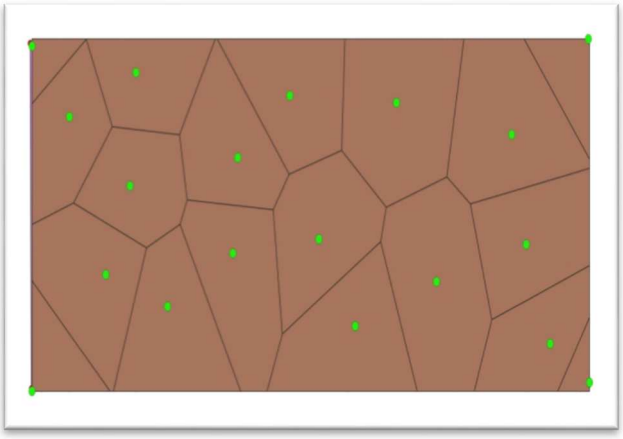

Fig. 6. Voronoi Partitioning

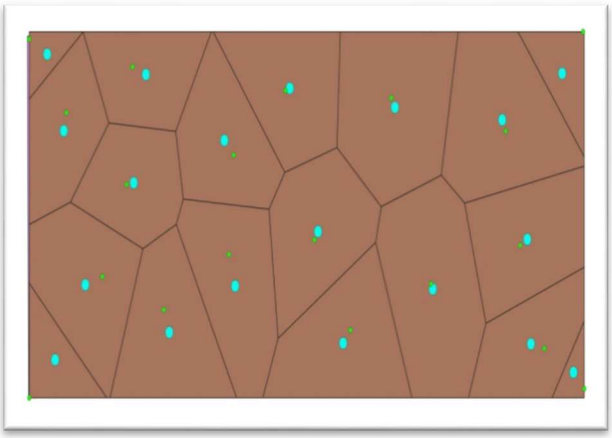

Fig. 7. Computation of Centroids

IV. Results And Discussion

The implementation of the proposed work was done the QGIS 3.10.0 with GRASS 7.8.0. The various results that we have obtained from the proposed algorithm is discussed in this section. Initially we have computed the coordinates of the obstacles and a sample of it is depicted in Table 1. Once the coordinates are obtained, we partition the area using voronoi partitioning algorithm and obtain various partitions. The details of the partitions such as the areas and perimeter are tabulated in Table 2. Once the partitions are obtained, we need to compute the centroids and the coordinates of the centroids computed is shown in Table 3. Once the centroids are computed we obtain these as the coverage points and pose it as a TSP problem. Now the vehicle needs to traverse all the points with minimal distance. To obtain this we have chosen various algorithms and observe how it works for our partitioned graphs.

TABLE I. Obstacles

id	xcoord	ycoord
1	79.29174	12.17417
2	79.27643	12.18348
3	79.27593	12.17714
4	79.2739	12.17219
5	79.27907	12.1704
6	79.28454	12.17338
7	79.28495	12.17873
8	79.2893	12.1822
9	79.29822	12.1818
11	79.29478	12.16931
12	79.30157	12.17179
13	79.30785	12.18002
14	79.30907	12.17387
15	79.3111	12.16832
16	79.26772	12.18497
17	79.31434	12.18537
18	79.31444	12.16614
19	79.26772	12.16565

TABLE II. Geometric Attributes - Voronoi Partitioning

id	Area	Perimeter
1	5.83E-05	0.030547
1	4.32E-05	0.026957
2	4.23E-05	0.02797
3	4.41E-05	0.025907
4	5.99E-05	0.031217
5	5.93E-05	0.032899
6	6.05E-05	0.032
7	5.20E-05	0.029283
8	5.40E-05	0.031197
9	7.73E-05	0.034289
11	6.26E-05	0.034661
12	8.02E-05	0.034472
13	7.51E-05	0.034822
14	5.66E-05	0.03116
15	4.30E-05	0.027921
16	8.28E-06	0.013999
17	1.87E-05	0.021006
18	5.62E-06	0.011813
19	2.03E-05	0.021756

TABLE III. Centroids

id	xcoord	ycoord
1	79.29204	12.17461
1	79.27063	12.18003
2	79.27756	12.18306
3	79.27653	12.17723
4	79.27245	12.17175
5	79.27953	12.16919
6	79.28507	12.17168
7	79.28416	12.17952
8	79.28966	12.18232
9	79.29852	12.18129
11	79.29416	12.16861
12	79.30172	12.17152
13	79.30756	12.18062
14	79.30967	12.17419
15	79.30998	12.16857
16	79.26924	12.18416
17	79.31259	12.18312
18	79.31354	12.16703
19	79.2699	12.16771

Now the distance matrix is obtained for all the points and a complete graph is computed to be posed as TSP. Fig. 8 depicts the complete graph. Now we build a Minimum Spanning tree over the computed complete graph and try to solve the problem using algorithms like Greedy, Nearest Neighbor and Lin-Kernighan. From the table it is evident that the shortest path is obtained while using the Lin-Kernighan algorithm over the partitioned area obtained from the proposed algorithm. The representation of the path is as shown in Fig. 9. The results are tabulated in Table 4.

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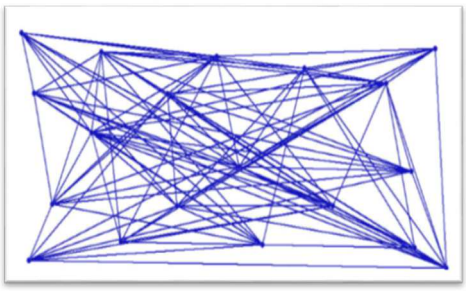

Fig. 8. Complete Graph

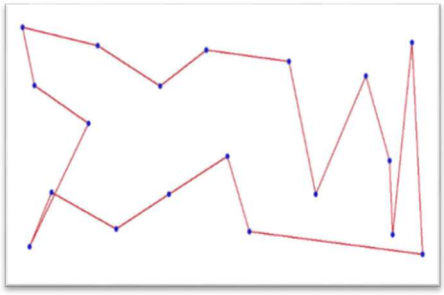

Fig. 9. Solving TSP using Lin-Kernighan

TABLE IV. COMPUTATION OF ERROR (%)

Proposed Algorithm	Edges	Distance(mm)	Execution time(s)
Greedy Approach	19	25250015	1.19
Nearest Neighbor	19	23159578	1.46
Lin-Kernighan	19	22159578	1.08

V. CONCLUSIONS

An important study and application area for UAVs is path planning, which typically dictates the efficiency with which an unmanned aerial vehicle (UAV) performs its mission. The biggest problem is to ensuring that the area of interest is completely covered, eliminating any unnecessary or undesired coverage. Any approach must be carefully planned and calculated due to the fact that most areas have irregular, polygonal contours. In this paper we have proposed the use of Voronoi partitioning algorithm for efficient coverage of agricultural land. The autonomous vehicles are used for the coverage. One the partitioning is done it is posed as TSP problem ad is solved using various algorithm. Lin-Kernighan algorithm proves to be efficient both in terms of execution time and distance travelled for the proposed algorithm. A s a future work, use of dynamic obstacles can also be considered. Future work could also include path planning considering dynamic obstacles and also the direction of the wind.

REFERENCES

[1] Tsolakis, N., Bechtsis, D., & Srai, J. S. (2018). Intelligent autonomous vehicles in digital supply chains: From conceptualisation, to simulation modelling, to real-world operations. Business Process Management Journal.

[2] Akshya, J., & Priyadarsini, P. L. K. (2020). Graph-based path planning for intelligent UAVs in area coverage applications. Journal of Intelligent & Fuzzy Systems, 39(6), 8191-8203.

[3] Rokhmana, C. A. (2015). The potential of UAV-based remote sensing for supporting precision agriculture in Indonesia. Procedia Environmental Sciences, 24, 245-253.

[4] Mirza, M. N., Qaisrani, I. H., Ali, L. A., & Ali Naqvi, A. (2016). Unmanned Aerial Vehicles: A Revolution in the Making. South Asia Studies, 31(2), 243-256.

[5] Akshya, J., & Priyadarsini, P. L. K. (2019, February). A hybrid machine learning approach for classifying aerial images of flood-hit areas. In 2019 International Conference on Computational Intelligence in Data Science (ICCIDS) (pp. 1-5). IEEE.

[6] Tsouros, D. C., Bibi, S., & Sarigiannidis, P. G. (2019). A review on UAV-based applications for precision agriculture. Information, 10(11), 349.

[7] Karnawat, K., Asare, N., Singh, S. A., & Kulkarni, A. (2022). Autonomous UAV with Human Detection. In *Advances in Micro-Electronics, Embedded Systems and IoT* (pp. 297-303). Springer, Singapore.

[8] Muvva, V. V. R. M. K., Li, G., & Wolf, M. (2022). Autonomous UAV Landing on a Moving UAV using Machine Learning. In *AIAA SCITECH 2022 Forum* (p. 0789).

[9] Pietz, J., Wilck, J. H., Christensen, S., Melville, M., Stank, J. Q., & Zaiser, S. (2022). Autonomous Target Search Using Unmanned Aerial Vehicles in the Presence of Signal Noise. *IEEE Communications Letters*.

[10] Bishop, R. E. (2022). *Applications and Development of Intelligent UAVs for the Resource Industries* (Doctoral dissertation, Virginia Tech).

[11] Kour, K., Gupta, S., & Gupta, S. K. (2022). DEPLOYMENT OF MULTI-UAVS FOR MARS EXPLORATION. *JOURNAL OF HARBIN INSTITUTE OF TECHNOLOGY*, *54*(5), 2022.

[12] Latif, M. A. (2022). Improving stability of aerial videos acquired through vision sensors onboard UAVs for applications in precision agriculture. *Signal, Image and Video Processing*, *16*(5), 1263-1270.

[13] Boursianis, A. D., Papadopoulou, M. S., Diamantoulakis, P., Liopa-Tsakalidi, A., Barouchas, P., Salahas, G., ... & Goudos, S. K. (2022). Internet of things (IoT) and agricultural unmanned aerial vehicles (UAVs) in smart farming: A comprehensive review. *Internet of Things*, *18*, 100187.

[14] Kakamoukas, G. A., Sarigiannidis, P. G., & Economides, A. A. (2022). FANETs in Agriculture-A routing protocol survey. *Internet of Things*, *18*, 100183.

[15] Aslan, M. F., Durdu, A., Sabanci, K., Ropelewska, E., & Gültekin, S. S. (2022). A comprehensive survey of the recent studies with uav for precision agriculture in open fields and greenhouses. *Applied Sciences*, *12*(3), 1047.

[16] Agrawal, J., Kapoor, M., & Tomar, R. (2022). A novel unmanned aerial vehicle-sink enabled mobility model for military operations in sparse flying ad-hoc network. *Transactions on Emerging Telecommunications Technologies*, *33*(5), e4466.

[17] Cheng, Z., Liwang, M., Chen, N., Huang, L., Du, X., & Guizani, M. (2022). Deep reinforcement learning-based joint task and energy offloading in UAV-aided 6G intelligent edge networks. *Computer Communications*.

[18] Boutalbi, M. C., Riahla, M. A., & Ahriche, A. (2022). Enhanced UAVs Mobility Models for Surveillance and Intruders Detection Missions. *Arabian Journal for Science and Engineering*, 1-17.

[19] Du, H., Sun, T., Lv, M., Junhui, M., & Zhang, Z. (2022). Dynamic coverage performance of wind-assisted balloons mesh base on Voronoi partition and energy constraint. *Advances in Space Research*.

[20] Amaya-Gómez, R., Schoefs, F., Sánchez-Silva, M., Muñoz, F., & Bastidas-Arteaga, E. (2022). Matching of corroded defects in onshore pipelines based on In-Line Inspections and Voronoi partitions. *Reliability Engineering & System Safety*, *223*, 108520.

[21] Razzaghi, N., & Babaie, S. (2022). A new selfish thing detection method based on Voronoi diagram for Internet of Things. *The Journal of Supercomputing*, *78*(6), 8389-8408.

[22] Navaneetha Krishnan Rajagopal, Naila Iqbal Qureshi, S. Durga, Edwin Hernan Ramirez Asis, Rosario Mercedes Huerta Soto, Shashi Kant Gupta, S. Deepak, "Future of Business Culture: An Artificial Intelligence-Driven Digital Framework for Organization Decision-Making Process", Complexity, vol. 2022, Article ID 7796507, 14 pages, 2022. https://doi.org/10.1155/2022/7796507

[23] Eshrag Refaee, Shabana Parveen, Khan Mohamed Jarina Begum, Fatima Parveen, M. Chithik Raja, Shashi Kant Gupta, Santhosh Krishnan, "Secure and Scalable Healthcare Data Transmission in IoT Based on Optimized Routing Protocols for Mobile Computing Applications", Wireless Communications and Mobile Computing, vol. 2022, Article ID 5665408, 12 pages, 2022. https://doi.org/10.1155/2022/5665408

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